

sol solution are mixed, <sup>the</sup> the most of <sup>the</sup> voids occurred after stacking is filled by the ceramic sol and the sol is transferred to <sup>the</sup> ceramic particles during <sup>the</sup> thermal treatment process, after the film formation, so that voids substantially decrease.

5 And ~~As~~ the ceramic sol itself has electric charge and is compatible with both the ultrafine ceramic oxide powder and the solvent, it is feasible <sup>to x h. o. i. e</sup> of stabilization of the suspension and the surface electricity charge treatment of the ultrafine ceramic oxide powder, even without <sup>a</sup> separate operation and pH control medium.

10 If a work electrode <sup>15</sup> attached <sup>to 1/3</sup> of substrate and an opposite electrode dip <sup>pad</sup> into <sup>the</sup> sol solution <sup>to note f</sup> mixed of the ultrafine ceramic oxide powder and the ceramic sol solution, the ceramic sol and the ultrafine ceramic oxide powder polarized in the sol solution phase move to the work electrode to form a film on the substrate ~~attached at the work electrode.~~

15 Metal, resinous polymeric organic compound, or ceramics may be used as a vibration plate.

20 As ~~For~~ the metal for the vibrating plate, nickel (Ni) or stainless steel is mainly used; as for the resinous polymeric organic compound, polyester, polyimide, or teflon resin is mainly used; and as for the ceramics, alumina ( $Al_2O_3$ ), zirconia ( $ZrO_2$ ), silicon (Si), silicon carbide (SiC), silicon nitride ( $Si_3N_4$ ), silicon dioxide ( $SiO_2$ ), or glasses is mainly used.

25 At this time, it may be postfinished after generally forming the film on <sup>1/2</sup> substrate, or <sup>a</sup> screen, mold, or mask might be set on the substrate so as to form a piezoelectric/electrostrictive film element of desired type.

~~Whence~~ <sup>It</sup> is preferable to form the piezoelectric/electrostrictive film element <sup>with a</sup> ~~in the~~ thickness of 1-100  $\mu\text{m}$ , and ~~may be~~ more preferable to form <sup>if with a</sup> ~~in the~~ thickness of 5-30  $\mu\text{m}$ .

5 The formed piezoelectric/electrostrictive film is thermally treated to remove the remaining solvent and <sup>to</sup> ~~convert~~ the contained sol into fine ceramic particles. Thus the solvent is removed by thermal treatment and the ceramic sol acts as a reaction medium on oxide particle surface to induce the bonding between ultrafine ceramic oxide particles.

10 The reason for the reaction <sup>is</sup> ~~is~~ sufficient only by the thermal treatment at ~~the~~ low temperature of 100-600°C, is that a reaction <sup>the</sup> ~~same~~ as a sintering may take place by mutual reaction of bonding between the ultrafine ceramic oxide powder and the raw material of the constituent ceramic elements in the ceramic sol solution. And <sup>so</sup> ~~so~~, the added organic materials are removed during the thermal treatment.

15 Specifically in case of the polymeric organic compound, because the substrate may be damaged if thermally treated above 500°C, it is preferable to thermally treat it at 100-300°C, ~~in~~ <sup>in</sup> ~~case where~~ the polymeric organic compound is used as a substrate.

20 ~~So~~ <sup>More</sup> preferably, thermal treatment may be conducted at 150-300°C, which temperature range can suitably secure the crystallinity and formability of the piezoelectric/electrostrictive film element, <sup>all right</sup> ~~even as~~ the range is for the thermal treatment at considerably low temperature.

25 ~~And~~ <sup>The</sup> method ~~mat~~ <sup>may</sup> further comprise a step of drying the formed piezoelectric/electrostrictive film element before the

thermal treatment, after forming the piezoelectric/electrostrictive film element, <sup>and</sup> whence it is preferable to dry the piezoelectric/electrostrictive film element at 70-100°C.

5 The piezoelectric/electrostrictive film element obtained by the method is excellent in characteristics proper of ceramics, although the element has been thermally treated at low temperature.

So as for the present invention as above, energy required for electrophoretic deposition process is reduced because the ultrafine ceramic oxide powder is used and there is a low energization effect of the producing method, because the piezoelectric/electrostrictive film element can be formed where the stacking status of the particles is very dense even only with the thermal treatment at low temperature.

Now the present invention will be explained in detail by the following practical examples. But the following application examples are only illustrations of the present invention and do not <sup>limit</sup> ~~confine~~ the extent of the present invention.

[Example 1]

20 1 g of fine powder PZT-PMN was added into methoxyethanol 300 ml and acetyl acetone 20 ml, and 1 g of PZT sol was added into the mixed solution. Then, it was dispersed for 30 minutes by an ultrasonic generator. Afterwards it was agitated by a magnetic stirrer.

25 A SUS 316L plate fixed <sup>to the</sup> ~~on~~ silicon substrate and mask was prepared as a work electrode and a SUS plate of <sup>the</sup> same area was prepared as an opposite charge electrode. The electrodes were put <sup>as</sup> into the suspension and were connected to electric supply to